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Short communication

Restoring the Florida Everglades
Comments on the current reservoir plan for solving harmful algal blooms and restoring the Florida Everglades

William J. Mitsch

Juliet C Sproul Chair for Southwest Florida Habitat Restoration, Everglades Wetland Research Park, Florida Gulf Coast University, 4940 Bayshore Drive, Naples, FL 34112, USA

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PREFACE

This is an updated version of a review written by the author in April 2018 at the request of The Friends of the Everglades, an NGO based in Miami, Florida, on a plan developed primarily by the South Florida Water Management District (SFWMD) to mitigate coastal pollution that has resulted from discharges from Lake Okeechobee to the Gulf of Mexico and Atlantic coastline and eventually to "send the water south" to the Florida Everglades instead. This EAA Reservoir project was included by the U.S. Army Corps of Engineers in a 2018 U.S. Congressional bill that was approved. In May 2019, U.S. President Donald Trump pledged to spend $200 million to begin construction of this restoration, three times the amount requested by the state of Florida. While supported with enthusiasm by the Florida state legislature, the SFWMD, and some NGOs such as The Everglades Foundation, a change in leadership in the state of Florida after November 2018 elections and especially in the leadership of the South Florida Water Management District (SFWMD) has led to a renewed public optimism for major improvements in water quality management in south Florida. It is therefore timely for this review of the advantages and shortcomings of this "EAA (Everglades Agricultural Area) Reservoir Plan" to be widely disseminated in an international forum such as Ecological Engineering to encourage discussions among scientists and engineers.

1. Introduction

The Florida Everglades restoration is now at a crucial crossroad that will determine its long-term success or failure, so I consider it prudent to make some comments on the EAA Reservoir Plan as it is currently described. We were unable to delve into the details of hydrologic modeling performed by the South Florida Water Management District (SFWMD) related to this project given the short time allowed for comments and lack of support for a rigorous modeling effort, but I am providing this hopefully constructive critique so that the U.S. Army Corps of Engineers and the SFWMD can fine-tune the EAA Reservoir Plan so that it becomes a significant step forward toward completion of a sustainable Florida Everglades restoration.

I first express my support for an ambitious effort to eliminate decades of stalling with a serious "sending the water south" strategy, the mantra for a generation of those who understand the big picture of what the Florida Everglades restoration is all about. The South Florida Water Management District claimed that the EAA Reservoir project will — when used in conjunction with other existing and planned projects — reduce the number of damaging discharge events from Lake Okeechobee to the St. Lucie and Caloosahatchee rivers by 63% and increase the flow going south to the Everglades and Florida Bay by 76% from 0.26 to 0.46 billion m^3/year (160,000 to 370,000 acre-ft/year).

But if this plan results in pollutants, particularly phosphorus and nitrogen, getting into greater Everglades water conservation areas (WCAs) and south to the Everglades National Park, or develops an unsustainable, un-ecological and/or simply polluted reservoir to manage in perpetuity, we will regret the day we said OK "just to spend the money." I am not assured from what I see written so far that this project is properly focused on what is important—sending clean water to the greater Florida Everglades. If ever there was a time for an ecological engineering and not just civil engineering approaches to lead the Everglades restoration, it is now.

2. Background

One-third of the original Florida Everglades was drained during the 20th century and converted into productive agricultural land (EAA), mostly for sugar farms. Eventually $1 to 2 billion dollars of Florida taxpayers' money was spent to create and maintain treatment wetlands (called stormwater treatment areas (STA)) to treat runoff rich in nutrients from this EAA to protect the downstream Everglades National Park. The Florida Everglades is currently in the middle of a many-decades, multi-billion US $ restoration plan. As I stated in an editorial

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in *Ecological Engineering* three years ago:

> "There is currently major concern being expressed throughout Florida USA about the recent pulses of an excessive amount of polluted farm water from the 1890-km^2 shallow and eutrophic Lake Okeechobee (also known as "Lake O") into the Caloosahatchee River to the west and into the St. Lucie River to the east by the U.S. Army Corps of Engineers (Fig. 1). This is part of the scheme for managing hydrology in the 46,000-km^2 Greater Florida Everglades, one of the largest wetland restorations in the world" Mitsch (2016).

Major coastal pollution, unanticipated in the original Everglades restoration plan, has accelerated recently, particularly in 2013, 2016, and 2018. The coastal pollution of estuaries, freshwater rivers, wetlands and even beaches has sidetracked and even threated to derail the restoration of the Florida Everglades that was once viewed primarily as a hydrologic project but now has become much more focused on water quality. If this same Lake Okeechobee water is discharged south to the Everglades and is not dramatically improved in water quality to low concentrations of phosphorus and nitrogen, then the project needs dramatic redesign to focus much more on water quality rather than only moving massive quantities of water around annually.

3. The plan

A current plan, referred to as C240A (Smith, 2018), calls for sending Lake Okeechobee water to an "EAA Reservoir" to be constructed about 50 km (30 miles) south of Lake Okeechobee with the following design: A 7-m (23-foot)-deep, 4087-ha (10,100-acre) reservoir with the capacity to store up to 300 million m^3 (240,000 acre-ft or 78.2 billion gallons) of excess Lake Okeechobee water (Fig. 2). The plan also involves completion of a previously approved 6070-ha (15,000–acre) A-1 Flow Equalization Basin with a maximum water storage of 74 million m^3 (60,000 acre-feet or 20 billion gallons) and the design and construction of 2630 ha (6500 acres) of shallow treatment wetlands, sometimes referred to by the SFWMD as Stormwater Treatment Areas (STAs), similar to the 25,600 ha (63,200 acres) of STAs already created or in progress to clean other EAA polluted stormwater prior to discharge to the Everglades (Fig. 3).

4. Concerns

1. My first comment concerns the false expectations by the public now that they see government approvals of up to $2 billion for this EAA project. I have frequently heard "Well the project is not perfect, but let's do it while the money is there." The volume of water being discharged south needs to be put in perspective; the 0.46 billion m^3/year (121 billion gallons/year) of water eventually being sent south to the Everglades and Florida Bay in the EAA reservoir plan will not solve the estuarine pollution of the Gulf of Mexico and Atlantic Ocean coastlines. Fig. 1 illustrates the Everglades Restoration plan that I have included in several editions of my books since we first published it in the Mitsch and Jørgensen (2004) ecological engineering book 15 years ago and it continued to be published in the 4th and 5th editions of "Wetlands" (Mitsch and Gosselink, 2007, 2015). I am aware that the restoration plan shown in the 3rd panel has been changed in several more recent publications and in prominent locations including the well-known wall maps at Corkscrew Swamp Sanctuary lobby in Naples, Florida, that now suggests there will always be significant water flowing east and west to the coastal estuaries even when the restoration is complete. It is not clear that the public is aware that this subtle change in graphics represents a major change in the overall restoration goals of the Florida Everglades in the past decade.
2. To put 0.46 billion m^3 of water per year (121 billion gallons per year) in perspective, 3.1 billion m^3 (819 billion gallons) were discharged to the St. Lucie and Caloosahatchee rivers in the El Nino flooding year of 2016 (Table 1), 6.2 times the flow expected to go south with the EAA Reservoir plan. Even in the 10- year period of 2008–2017, an average of 1.5 billion m^3 per year (Table 1) is 3 times the 0.5 billion m^3 per year that will be sent south according to the plan.
3. There is insufficient detail on water quality in the plan relative to

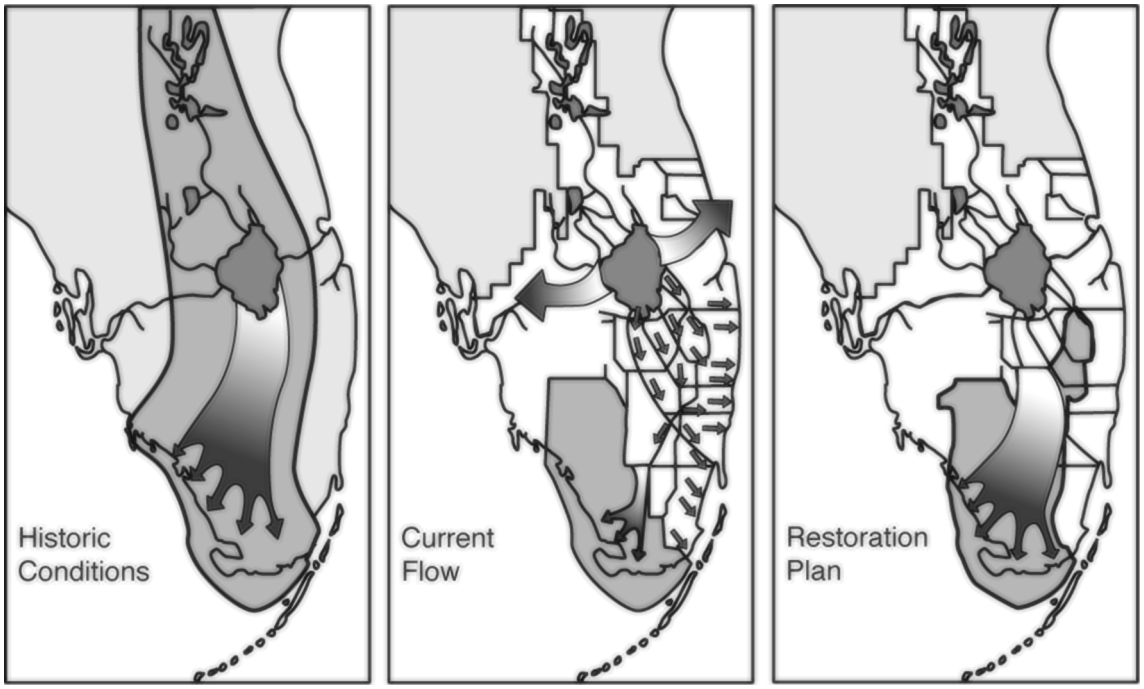

Fig. 1. Three-picture summary of historic, current, and restoration water flow in the Florida Everglades as provided by the U.S. Army Corps of Engineers in the early 2000s (from Mitsch and Jørgensen, 2004).

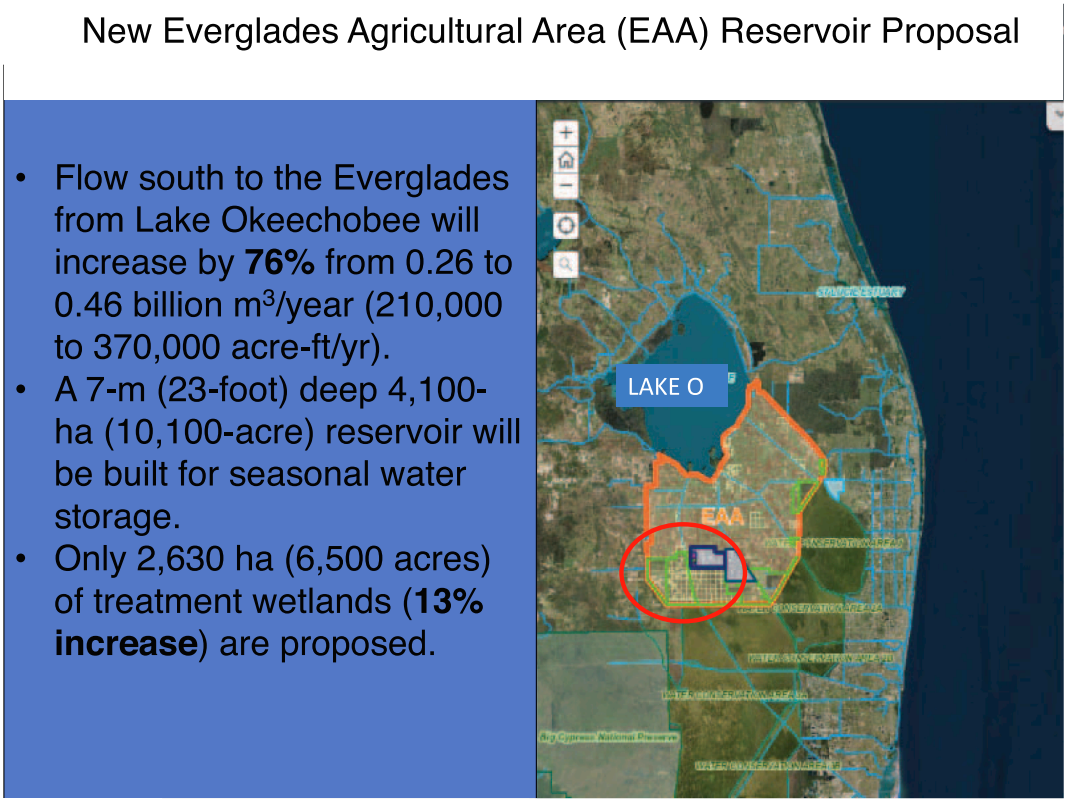

Fig. 2. Major features and map illustrating the location of the proposed Everglades Agricultural Area (EAA) Reservoir Plan in south Florida. Flow of polluted water from Lake Okeechobee will be directed to public lands south of the EAA region to a reservoir and flow-equalization basin system with 2600 ha of treatment wetlands toward the Florida Everglades to the south of the EAA. (Map based on one supplied by SFWMD).

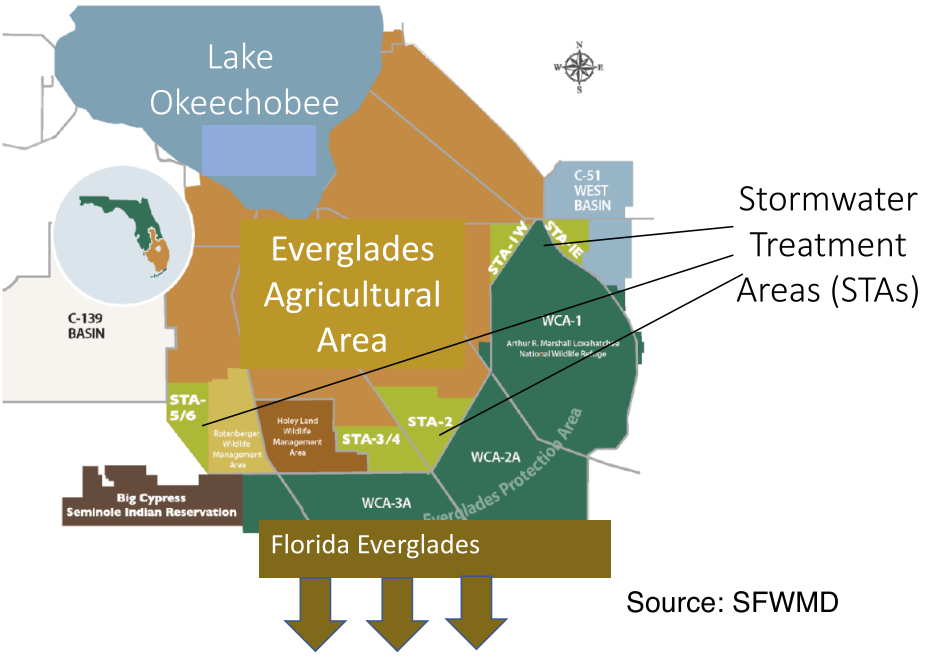

Fig. 3. Illustration of location of current treatment wetlands (called locally STAs or stormwater treatment areas) south of the EAA. There is no clear indication if these wetlands will receive double duty with additional inflows from the EAA Reservoir Plan. Currently 25,600 ha (63,200 acres) of these wetlands have been created or are on the drawing boards to be created. Our conservative estimate is that 40,000 ha (100,000 acres) more of these treatment wetlands will be needed to ensure that the EAA Reservoir Plan will be successful.

water volume and flow. The flow south to the Everglades will increase by 76% from 0.26 million m^3/year (210,000 acre-ft/year or 68 billion gallon/yr) to 0.46 billion m^3/year (370,000 acre-ft/yr or 121 billion gallon/yr) according to the EAA Reservoir plan (Smith, 2018). Despite the 76% increase in flow, the project shows only an 11% increase in treatment wetlands of 2630 ha (6500 acres) to improve water quality directly. I estimate an additional minimum of at least 17,500 ha (43,000 acres) of treatment wetlands (STAs or passive wetlands) will be needed to treat the water flowing south and have recommended previously that 40,000 ha (100,000 acres) should be set aside for treatment wetlands (Mitsch, 2016) to allow for a safety factor of 2, a reasonable design allowance for this type of ecological engineering project.

4. Further, we note that the estimated average concentration of total

Table 1
Freshwater discharges from Lake Okeechobee to the sea over the 10-year period 2008–2017, and annually in 2013, 2016, 2017, and 2018.

Discharge from Lake Okeechobee	2008–2017	2013	2016	2017	2018
Discharge to Caloosahatchee and Gulf of Mexico ($\times 10^9$ m^3)	1.3	1.6	2.2	1.7	1.1
Discharge to St. Lucie and Atlantic Ocean ($\times 10^9$ m^3)	0.2	0.6	0.9	0.6	0.4
TOTAL Discharge to the sea ($\times 10^9$ m^3)	1.5	2.2	3.1	2.3	1.5
Equivalent depth of Lake O discharged to sea (m)*	0.8	1.1	1.6	1.2	0.8

Discharge data from:
USGS 02292010 CALOOSAHATCHEE CANAL DWS OF S-77 AT MOORE HAVEN FL.
USGS 02276877 ST. LUCIE CANAL BLW S-308.
*Based on Lake Okeechobee surface area of 1891 km^2 (730 mile^2).
Source: https://en.wikipedia.org/wiki/Lake_Okeechobee.

phosphorus flowing out of Lake Okeechobee will be higher than the current concentrations of total phosphorus flowing into the current STAs (SFWMD, 2018). Due to the higher flow, it is probable that the phosphorus concentrations reaching future treatment wetlands (STAs) will be higher than the concentrations reaching the current STAs and, in that case, will threaten existing state and federal standards on Everglades water quality.

5. The new EAA Reservoir will not resemble any natural feature of aquatic ecosystems in the greater Florida Everglades in ecology, morphology or hydroperiod. It will in no way represent "restoration" of the Florida Everglades as it sometimes being portrayed. The hydroperiods will be wrong and exaggerated for south Florida ecology, similar to the way in which wetland hydroperiods were shifted in the Great Lakes coastal marshes with the diking of marsh hunt clubs and conservation areas (Mitsch et al., 2001; Mitsch and Gosselink, 2015). The potential amplitude of the annual hydroperiods of up to 7 m (23 feet) in the EAA reservoir is exceeded only rarely in natural or human-created ecosystems, e.g., the Amazon River (Junk et al., 1989) or Three Gorges Dam reservoir (Mitsch et al., 2008). The reservoir may become a "freak ecosystem" over time, i.e., an aquatic ecosystem dissimilar in hydrology and probably ecology to any other aquatic ecosystem in Florida.
6. Most eutrophic lakes in our experience become occasional or even permanent sources rather than sinks of nutrients—Buckeye Lake, Ohio (W.J. Mitsch, personal experience), Taihu Lake in China (Kelderman et al., 2005), and even Lake Okeechobee (Havens and James, 2005). It is highly probable that the EAA Reservoir will not be a nutrient sink in most years, although that is an assumption included in this plan. Using a Vollenweider-type model (Hejzlar et al., 2006) in SFWMD's Dynamic Model for Everglades Stormwater Treatment Area (DMSTA) model as proof that the EAA Reservoir will always be a nutrient sink is ecologically and hydrologically inaccurate and misleading. The DMSTA model was developed to evaluate multiple STA design alternatives. Model simplicity resulted from aggregation of key variables and processes controlling phosphorus storage and cycling (Walker and Kadlec, 2011). But the DMSTA has not been calibrated for reservoirs.

5. Conclusions

- The EAA Reservoir Plan is considered the future heart of this recent attempt to send water south in the Florida Everglades and is a good start of the discussion of solving water excess and scarcity problems. The Florida State Legislature and the South Florida Water Management District plan to increase the southerly flow by 76% and send an annual average of 0.45 billion m^3 (121 billion gallons) of water south to the Everglades and Florida Bay is noteworthy.
- Nevertheless, there is considerable ambiguity in the plan and its model predictions about the quality of the water as it enters the greater Everglades south of the EAA Reservoir and through Miccosukee Tribal lands on its way to the Everglades National Park and Florida Bay. At a minimum, approximately 20,000 ha (50,000 acres) and hopefully more than 40,000 ha (100,000 acres) of treatment wetlands (STAs) need to be created or restored in proximity to the new EAA Reservoir; 2630 ha (6500 acres) of new treatment wetlands as described in the EAA Reservoir Plan will be grossly insufficient to protect the Everglades.
- The plan for an EAA Reservoir immediately south of Lake Okeechobee should be re-examined. For example, purchase of farmland at a fair price coupled with conversion of that land to treatment wetlands (perhaps as much as 60,000 ha (150,000 acres) from the 280,000 ha (700,000 acre) EAA in lieu of construction of a ~$2-billion EAA reservoir is a reasonable alternative to the reservoir for water storage and water quality and should be examined. Additionally, state-owned lands currently leased to agricultural tenants could be incorporated in any comprehensive review of alternatives. Providing treatment wetlands to achieve water quality goals in the Florida Everglades is closer to true "restoration"; creation of large difficult-to-manage deep reservoirs is not. Federal acceptance of this plan needs to be conditioned with the requirement of adequate stormwater wetlands (STAs) and flow equalization basins (FEBs), to mitigate the chances of falling short.

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